Experimental study on the role of thermal feedback from different wall linings in a room fire

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Experimental study on the role of thermal feedback from different wall linings in a room fire

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Room scale experiments on round heptane pools showed that:

- **thermal feedback can lead to an increase of the heat release rate which may lead to thermal runaway**
- **before thermal runway the increase of the heat release rate correlates well with lining temperatures irrespectively of the type of lining material**
- **different thermal inertias of the linings are found to lead to different onset points for thermal runaway**
- **results of fire tests on pool fires may be affected by the room an type of lining**

Introduction

Thermal feedback induce an increased heat release rate and lead to thermal runaway, TR [1]

The objectives of this experimental program [2] was to investigate the influence of different linings on the increase of heat release rate and thermal runaway.

Circular heptane pools are tested under room burn conditions and free burn conditions.

The experimental setup

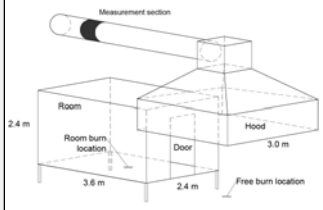
The ISO Room Corner Test facility was used.

The thermal feedback was changed by using two types of linings with substantially different thermal inertias.

- Lining 1 (mineral wool), kpc = 0.0036 kW^2s/m^4K^2
- Lining 2 (light weight concrete), kpc = 0.09 kW^2s/m^4K^2

Measurements included:

- heat release rate, mass loss rate,
- heat flux and
- temperatures (two thermocouple trees and back wall).



Free burn is tested under the hood

Room burn is tested in the center of the room

10 different tests were conducted for different pool sizes, burning conditions and linings comprising the following experimental matrix:

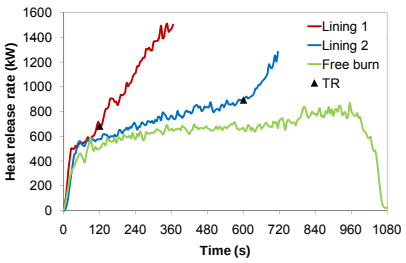
Test no.	Pan Diameter (m)	Amount of heptane (l)	Burning condition
1	0.70	25	Free burn
2	0.70	25	Lining 1
3	0.70	25	Lining 2
4	0.50	10	Free burn
5	0.50	10	Lining 1
6	0.50	10	Lining 2
7	0.50	15	Lining 2
8	0.35	4	Free burn
9	0.35	4.2	Lining 1
10	0.35	4.2	Lining 2

Results

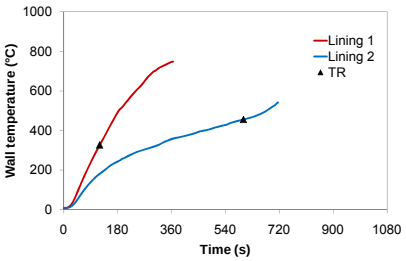
Only the tests with the large pools had a large enough energy to show a clear effect of thermal feedback.

Measurements of HRR and temperatures, in this case given as the wall temperature measured 2.0 m above the floor, showed that for both types of lining the HRR increased slightly in an incipient period followed by a rapid increase compared to free burn. The rapid increase is interpreted as a thermal runaway, which can be associated with flashover. Temperatures follows the trend of the development of the HRR.

Heat release rate



Wall temperature



References

[1] Thomas PH, Bullen ML, Quintiere JG and McCaffrey B (1980) Flashover and instabilities in fire behavior. Combustion and Flame 38:159-171.

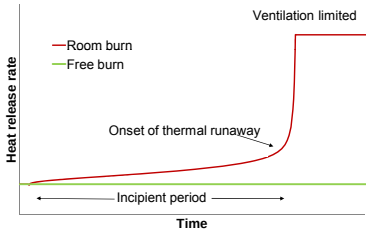
[2] Poulsen A and Jomaas G (2011) Experimental study on the burning behavior of pool fires in rooms with different wall linings. Fire Technology, DOI : 10.1007/s10694-011-0230-0

Effect of the thermal feedback

The effect of the thermal feedback on the development of the HRR can be found as [1]:

$$\dot{Q}_F = \dot{Q}_0 + A_F \cdot \Delta H_{eff} \cdot \left(\frac{\dot{q}''_{ext}}{L_g} \right)$$

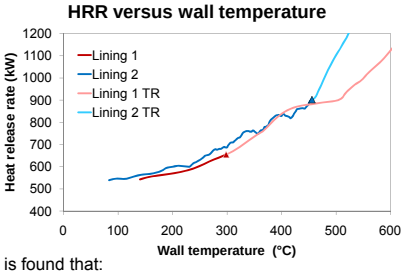
As the HRR increases initially compared to free burn this can be seen as an effect of the thermal feedback from the room before thermal runaway occurs. After the thermal runaway the HRR is theoretically only limited by ventilation. This is summarized in the figure below.



Effect of different linings

By comparing the HRRs and the wall temperatures, it can be seen that the different linings show similar results until the onset of thermal runaway, at which point the two materials yield drastically different results.

HRR versus wall temperature



It is found that:

- The HRRs are comparable for same temperatures before thermal runaway but not after.
- For lining 1 thermal runaway occurred at a wall temperature of 330 °C and for lining 2 thermal runaway occurred at 460 °C, showing that the onset temperature is higher for higher thermal inertia.